Epidemiology of *Echinococcus granulosus* infection in the central Peruvian Andes

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The prevalence of human, canine, and ovine echinococcosis was determined in an endemic area of the Peruvian Andes where control programmes have not been operational since 1980. Prevalence of infection in humans was determined using portable ultrasound, chest X-rays, and an enzyme-linked immunoelectrotransfer blot (EITB) assay. Canine and ovine echinococcal prevalence was determined by microscopic stool examinations following arecoline purging for tapeworm detection and by examination of the viscera from slaughtered livestock animals, respectively.

The prevalence among 407 humans surveyed was 9.1%. The frequency of disease in the liver, lung, and in both organs was 3.4%, 2.0%, and 0.2%, respectively. Portable ultrasound or portable chest X-ray has shown that, compared to adults, children under 11 years had significantly higher seropositive rates without evidence of hydatid disease ($P < 0.05$). Among the 104 dogs inspected for echinococcus after arecoline purging, 33 (32%) were positive for adult tapeworms. Among the 117 sheep slaughtered at the local abattoir, 102 (87%) had hydatid cysts.

The prevalence of human hydatidosis in this endemic area of Peru is one of the highest in the world and nearly five times higher than previously reported in 1980. An increase in echinococcosis prevalence may result after premature cessation of control programmes.

Introduction

Human hydatidosis caused by *Echinococcus granulosus* is endemic in the sheep-rearing regions of Peru (*1*, *2*), where echinococcosis has been recognized as a major public health problem (*1–3*). However, prevalence surveys have not been conducted in intermediate, definitive, or accidental hosts since 1980; most studies were carried out in the 1970s in the central Andean department of Junín (*4*). At that time a pilot hydatidosis control programme was initiated in the farming cooperative Tupac Amaru (*3*), but these efforts were abandoned 17 years ago largely due to political instability. In 1980, when the control programme ceased, the prevalence of echinococcal infection in dogs and sheep was 1.6% and 5%, respectively (*3*, *5*).

Use of enzyme-linked immunolectrotransfer blot (EITB) and double-diffusion (DD5) assays on serum collected in 1989 from Tupac Amaru revealed a seroprevalence of 1.9% in 309 individuals (*6*). While the EITB assay is useful in the diagnosis of human hydatid disease, the sensitivity is only 65%; hence the prevalence was probably an underestimate (*7*).

The present epidemiological study was conducted in Tupac Amaru from September 1994 until October 1995, using the EITB assay, as well as portable ultrasonography (US) and portable chest X-rays to determine the prevalence of human hydatidosis. A case–control study was undertaken to identify environmental and cultural factors important in *E. granulosus* transmission, and the prevalence of echinococcal infection in farm animals and dogs was also determined.

This study was approved by the ethical review boards of the Universidad Peruana Cayetano Heredia, the Universidad Nacional Mayor de San

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Marcos, The Johns Hopkins University, and the Council of Tupac Amaru. Free and informed consent was obtained from the study subjects.

Materials and methods

Study site. Tupac Amaru is a farming cooperative occupying an area of 21.7 km^2 in the central Peruvian Andes at altitudes between 3600 m and 4300 m above sea level. The terrain is mostly mountainous with few valleys and streams. Sheep are the dominant livestock (99 300 animals), but cattle (3370) and alpacas (4300) are also raised for human consumption; horses (609) are used as pack animals. Pigs are absent, except in nearby rural communities not belonging to Tupac Amaru.

The cooperative consists mainly of adobe houses with wooden floors and piped river water, but most have no electricity. Families use toilet drains, borehole latrines or nearby streams for defecation. Some workers and their families live in these houses, while the shepherds live in widely dispersed shacks with dirt floors and no electricity. Shepherds routinely use dogs to care for the flocks of cooperatively owned sheep. Medical facilities are often 5–20 miles distant.

Study design. A community census was performed first, the questions to families including those on their knowledge of hydatidosis transmission. The study was carried out in two phases. First, surveys of humans, dogs, and livestock for echinococcal infection; second, a case–control study to determine factors important in *E. granulosus* transmission.

Epidemiological survey. Meetings were held to explain the purpose of the study to members of the cooperative. Two teams conducted the survey. A medical team carried out ultrasonic scanning of human subjects older than 5 years and collected serum samples. A second team of veterinarians purged the dogs and collected faecal samples, and examined the viscera of slaughtered livestock for echinococcal cysts. The teams worked on market days when the shepherds frequently come to the cooperative.

Cases with presumptive hydatidosis were informed of the findings and referred by the physician in the health post to a national health insurance hospital in Oroya or Huancayo for surgical or medical treatment.

Ultrasound survey. Individuals were examined in the supine position, using a Shimasonic (Shimadzu, Nishinokyo-Kuwauaracho, Kyoto, Japan) SDL-32, 3.5 MHz, portable ultrasonograph powered by a portable 4-kW generator, with liquid paraffin as the transducing medium. Cysts were diagnosed using the scheme described by Gharbi et al. (*8*). Fluid-filled hepatic cysts without daughter cysts (solitary) and fluid-filled cysts with septa (daughter cysts) were considered to be hydatid cysts. Hepatic cysts with a heterogeneous echographic pattern or calcification were considered to be presumptive hydatid cysts (*8*, *9*). Renal cysts were not considered as hydatid, since idiopathic renal cysts are common (*10*).

Enzyme-linked immunoelectrotransfer blot (EITB) assay. An EITB assay for human hydatid disease diagnosis, which identifies three antigens of $M_r = 8 \times 10^3$, 16×10^3 and 21×10^3, was performed as previously described except for the following modifications: antigen was used at twice the previous concentration (0.2 mg/ml) and 20 µl of human serum at 1 : 50 dilution was used instead of 10 µl at 1 : 100 dilution (*7*). A positive result was defined as the presence of any of the above bands.

Chest X-ray. Posterior–anterior chest radiographs were taken at the cooperative's health post in March 1995 using a portable machine. Films were read by a radiologist (*BS*), with no knowledge of the serological and ultrasound results. Technically deficient chest-X rays were repeated. Beggs' criteria for lung hydatid disease were used for diagnosis of pulmonary hydatidosis (*11*).

Arecoline purging of dogs. Dogs were given an oral dose of arecoline hydrobromide (4 mg/kg), as previously described (*12*). Faecal samples were collected from dogs that purged successfully according to WHO guidelines (*12*).

Slaughterhouse visits. The local abattoir was visited on slaughter days and the percentage of infected animals with hydatid cysts was noted. Conditions in the abattoir such as veterinary supervision, facilities for infected viscera disposal, and presence of dogs were observed. A total of 117 sheep and 25 cattle were inspected during a 2-month period. Pigs were not killed in the abattoir, but those in a community one kilometre away were inspected.

Surgical incidence of hydatidosis. Individuals from the cooperative with hydatid disease who were not part of our screening study were located by reviewing the local health post's records. All the workers were covered by national health insurance, but must first be evaluated at the local health post before referral to one of the national hospitals for surgery or other treatment.

Data analysis. Individuals who were examined by EITB, ultrasound, and chest X-ray were designated the examination cohort (EC). Those not surveyed at all or surveyed by only one or two methods were not part of this cohort and were designated the non-examination cohort (non-EC).

The χ^2 test was used to determine differences in categorical variables between the EC and the non-EC groups. Kappa analysis was used to test agreement between the different diagnostic methods used among EC subjects.

Case–control study design. Infected study subjects were compared to noninfected cooperative residents to identify the risk factors for hydatid disease. Cases of *E. granulosus* infection were defined as individuals with a positive EITB assay, and/or those with presumed liver or lung hydatid cysts diagnosed by ultrasound scanning or chest X-rays. Controls were defined as individuals who participated in the study and had a negative EITB, ultrasound and chest X-ray findings and no previous history of hydatid disease. One case was matched for age (±5 years) and sex with two non-infected controls. Controls were selected from the list of participants who met the above criteria using a random table. Cases and controls had a lateral chest X-ray taken at a clinic in Huancayo city to rule out hidden cysts, in addition to the posteroanterior chest X-ray.

Exposure of cases and controls to *E. granulosus* was assessed using a questionnaire to identify practices which might increase such exposure and knowledge regarding transmission. Questions included place of birth, level of education, and occupation; type of farm animals raised and/or slaughtered, and the place of slaughter (home, field, abattoir) and disposal of infected viscera; the number of dogs kept and their use (shepherd or pet), the place where they slept, and the type of food given to them. The individual's knowledge of what caused hydatidosis, how it was transmitted, and what type of disease it caused in humans and farm animals was also determined.

Data were analysed by standard methods for matched case–control studies. For the questionnaire data, odds ratios (OR) with 95% confidence limits were calculated for each item in the questionnaire. Questionnaire items that were significant at $P < 0.05$, or with high OR but borderline statistical significance ($P < 0.2$) in the initial univariate matched-pair analysis, were tested for inclusion in the logistic models. The conditional logistic statistical model for matched data implemented by Statistics Graphics Data Management (Stata Statistical Software: Release 4.0. Stata Corporation, College Station, TX, USA, 1995) was used to identify questionnaire items that were independently associated with an increased risk of *E. granulosus* infection.

Results

Human study

The census revealed 1042 individuals living in 238 households (52% males; mean age, 23 years (range 0–72 years)). As 155 (15%) were <6 years, there were 887 subjects who were potentially eligible for the study. The census revealed that 82% of households admitted they had seen hydatid cysts in animals, 65% had complete or partial knowledge of the cause of hydatid disease, 93% thought it was dangerous to both humans and animals, and 84% regarded dogs as a cause of transmission of the disease to humans.

A total of 407 individuals in the examination cohort (EC) were surveyed by all three methods. The EC and non-EC individuals were similar for most of the characteristics tested (Table 1).

Defining hydatid *infection* as a positive result in at least one of the three tests (EITB, ultrasound, and chest X-ray), we found the prevalence of human hydatidosis to be 9.1% (Table 2). Hydatid *disease*, defined as a positive result by ultrasound and/or chest X-ray (*8*, *11*), was present in 5.7% of individuals (23/407). The ratio of lung to liver cysts was 1:1.75. The frequency of seropositivity was 57% (8/14) in those with presumptive liver hydatid cysts and 38% (3/8) in those with presumptive lung hydatid cysts; the only case with cysts in both lung and liver was also EITB-positive. The overall seropositivity of presumptive images in any one organ was 52% (12/23).

Fourteen individuals were seropositive but were negative by ultrasound or chest X-ray (Table 3). None of the 23 individuals in whom presumptive liver or lung cysts were detected had symptoms associated with these lesions and only three had hepatomegaly on physical examination (Table 4). Four individuals with EITB-negative renal cysts lacked ultrasound criteria for hydatid cysts and were excluded from disease prevalence. Age, sex, and the specific findings by EITB, ultrasound and chest X-ray of the 23 individuals with presumptive hydatid cysts are shown in Table 4.

About 50% of family members were examined by all three methods (407/810). Subjects positive to any one method belonged to 34 households with 186 family members, 52% of whom (97/186) had three examinations performed. Three households had two members each with hydatid infection.

Table 1: **Characteristics of 407 individuals surveyed by three methods[a] for hydatid disease and of those not surveyed in Tupac Amaru, Peru, 1994–95**

	Examination cohort	Non-examination cohort[b]	*P* value[c]	Odds ratio	95% confidence interval
Age group:					
6–10 years	85 (20.9)[d]	87 (18)	NS[e]	NS	
11–15 years	74 (18.2)	101 (21)	NS		
16–30 years	71 (17.4)	138 (29)	<0.001	0.52	0.37–0.73
31–40 years	82 (20.1)	56 (12)	<0.001	1.91	1.30–2.82
41–50 years	54 (13.3)	45 (9)	NS		
>50 years	41 (10.1)	53 (11)	NS		
Total	407 (46)	480 (54)			
Mean age (years)	27	26	NS	NS	
Range (years)	6–69	6–72			
No. of males	203 (49.9)	266 (55)	NS		
No. of females	204 (50.1)	214 (45)	NS		
Educational level:					
Illiterate	24 (6)	41 (9)	NS		
Primary	243 (60)	259 (54)	NS		
Secondary	111 (27)	151 (31)	NS		
Beyond high school	29 (7)	29 (6)	NS		
Occupation:					
Shepherd	74 (18)	69 (14)	NS		
Student	170 (42)	201 (42)	NS		
Housewife	80 (20)	87 (18)	NS		
Other	83 (20)	123 (26)	NS		
House characteristics:					
Wood/cemented floor	311 (76)	329 (69)	<0.01	1.49	1.09–2.03
Dirt floor	96 (24)	147 (31)	<0.02	0.70	0.51–0.95
Adobe walls	224 (55)	298 (62)	<0.05	0.75	0.57–0.99
Concrete walls	98 (24)	70 (15)	<0.001	1.86	1.30–2.65
Dirt walls	66 (16)	83 (17)	NS		
Rock walls	19 (5)	29 (6)	NS		
Tin roof	386 (95)	445 (93)	NS		
Other	21 (5)	35 (7)	NS		
No. exposed to dogs	245 (60)	331 (69)	<0.01	0.68	0.51–0.91
No. exposed to sheep	126 (31)	173 (36)	NS	NS	
No. exposed to cattle	195 (48)	234 (49)	NS	NS	

[a] Enzyme-linked immunoelectrotransfer blot assay, portable ultrasonography, and portable chest X-ray.
[b] The non-examination cohort included subjects surveyed using only one or two methods.
[c] Significance by the χ^2 test.
[d] Figures in parentheses are percentages.
[e] NS: not significant.

Twenty-four children under 6 years of age were examined by ultrasound and chest X-ray at the parent's request. In a 5-year-old girl who was not part of the EC, a large hydatid cyst in the left lung was found, which was confirmed as hydatid after surgical excision. Two individuals positive by EITB and double-diffusion assays in the 1989 survey had seroconverted to negative and had no demonstrable disease by chest X-ray (in one) and ultrasound (in both).

Surgical incidence of hydatidosis. During a 1-year period, only one case of symptomatic pulmonary hydatid disease with haemoptysis presented to the hospital. This individual had previously refused to participate in the survey. A lung hydatid cyst was removed surgically at Oroya Hospital. The symptomatic incidence of hydatid disease in Tupac Amaru is 127 per 100 000, which is in sharp contrast to the asymptomatic rate of 2941 per 100 000 detected by ultrasound and chest X-ray.

Veterinary study

The prevalences of hydatid cysts in slaughtered sheep, cattle and pigs are shown in Table 5. Slaughterhouse facilities had no veterinary supervision and,

Table 2: **Age-specific prevalences of hydatidosis in 407 subjects surveyed by enzyme-linked immunoelectrotransfer blot assay (EITB), portable abdominal ultrasound (US), and portable chest X-ray (CXR) in Tupac Amaru, Peru, 1994–95**

Age group (years)	No. of subjects	Screened by: Serology (EITB) only: EITB + ve	Ultrasound (US) only: Cyst + ve	Radiology (CXR) only: Cyst + ve	Positive to EITB plus US and/or CXR[a]	Total positive
6–10[b]	85	6 (7.0)[c]	0 (0)	2 (2.4)	1 (1.0)	9 (10.6)
11–15	74	1 (1.4)	1 (1.4)	0 (0)	3 (4.0)	5 (6.8)
16–30	71	3 (4.2)	1[d] (1.4)	0 (0)	2 (2.8)	6 (8.5)
31–40	82	1 (1.2)	2 (2.4)	0 (0)	5 (6.1)	8 (9.8)
41–50	54	1 (1.9)	1 (1.9)	1 (1.9)	1 (1.9)	4 (7.4)
>50	41	2 (4.9)	2 (4.9)	1 (2.4)	0 (0)	5 (12.2)
Total	407	14 (3.4)	7 (1.7)	4 (1.0)	12 (3.0)	37 (9.1)

[a] Three subjects were EITB positive and had lung cysts; eight subjects were EITB positive and had liver cysts, and one was EITB positive and had liver and lung cysts. No patient was EITB negative with liver and lung cysts.
[b] There were significantly more seropositives by EITB in the 6–10-year-old group (χ^2-test; $P < 0.05$).
[c] Figures in parentheses are percentages.
[d] One subject had a right pleural effusion detected by both chest X-ray and ultrasound, and two small thoracic cysts were also found by ultrasound.

Table 3: **Comparison of results of combinations of enzyme-linked immunoelectrotransfer blot assay (EITB), portable abdominal ultrasound (US) examination, and portable chest radiography (CXR) for hydatidosis in 407 subjects, Tupac Amaru, Peru, 1994–95**

Results of tests for hydatidosis[a]	No. of subjects
EITB/US:	
+/+	9[b] (2.2)[c]
−/+	7 (1.7)
+/−	17[d] (4.2)
−/−	374 (91.9)
(Kappa analysis: $P = 0.39934$; fair agreement range, 0.41–0.60)	
EITB/CXR:	
+/+	4[e] (1.0)
−/+	4 (1.0)
+/−	22 (5.4)
−/−	377 (92.6)
(Kappa analysis: $P = 0.21159$; fair agreement range, 0.21–0.40)	
EITB/US and/or CXR:	
+/+	12 (3.0)
−/+	11 (2.7)
+/−	14 (3.4)
−/−	370 (90.9)
(Kappa analysis: $P = 0.45725$; moderate agreement range, 0.41–0.60)	

[a] +, positive for hydatidosis; −, negative for hydatidosis.
[b] One subject with a liver and a lung cyst is included.
[c] Figures in parentheses are percentages.
[d] Three subjects with lung cysts and EITB-positive are included.
[e] One subject with a liver and a lung cyst and three subjects with lung cysts are included.

in all our 10 visits, dogs were observed in and around the building feeding on discarded hydatid-infected viscera. A total of 104 dogs (63% of all dogs) were successfully purged; 33 (32%) were found to have adult echinococcus worms.

Case–control study

A total of 27 cases and 51 controls participated in the case–control study. Ten cases and 23 controls either left the cooperative or declined to participate in the interview.

Univariate analysis revealed no significant differences between cases and controls for the following variables: level of education, occupation (shepherd or other), time of exposure to dogs, slaughter practices at home, disposal of infected viscera, place where animals were slaughtered, and number of dogs kept in the past.

Knowledge of how hydatid disease occurred in humans was not a significant variable. Although not different between cases and controls, nearly half of the subjects (46%) had complete or partial knowledge about the cause of hydatidosis. A borderline or slight statistical significance was found for the following variables: raising sheep in the past, number of dogs owned in the past, owner's leftovers given as food to dogs, use of dogs for shepherding or as pet animals, and lack of knowledge of how hydatidosis was transmitted to humans.

Table 4: **Presumed hydatid cysts detected by imaging (ultrasound and X-rays) in 23 out of 407 (5.7%) individuals surveyed in Tupac Amaru, Peru, 1994–95**

Case, sex/age (years)	EITB[a] results	Observations		
		Ultrasound[b]	Radiological	Clinical
1,[c] F/46	–	Type 3, single hydatid liver cyst in right lobe (5)[d]	No cyst (N.C.) or symptoms	No signs (N.S.)
2,[c] M/45	+	Type 3, single hydatid liver cyst in right lobe (10)	N.C.	Hepatomegaly
3,[c] M/17	+	Type 3, multiple cysts in left liver lobe (7), 7 peritoneal cysts (3)	N.C.	N.S.
4,[c] F/35	–	Type 1, single hydatid liver cyst in left lobe (12)	N.C.	Hepatomegaly
5, M/9	+	Type 1, single liver cyst in right lobe (1.4)	N.C.	N.S.
6, F/40	+	Type 1, single liver cyst in right lobe (13)	N.C.	N.S.
7, M/39	+	Type 3, 5 liver cysts of various sizes, right and left lobes (7,7,4,4,1)	N.C.	Hepatomegaly
8, F/36	+	Type 1, single liver cyst in right lobe (15)	N.C.	N.S.
9, M/13	–	Type 3, single liver cyst in left lobe (6.3)	N.C.	N.S.
10, M/11	+	Type 1, single liver cyst in right lobe (5)	N.C.	N.S.
11, F/52	–	Type 1, single liver cyst in right liver lobe (4)	N.C.	N.S.
12, M/12	+	Type 1, 2 liver cysts in right lobe	Presumptive hydatid cyst of right lung (3)	N.S.
13, M/53	–	Type 4, small solid echogenic area in right liver lobe (0.9)	N.C.	N.S.
14, M/26	+	Type 4, small solid echogenic area in right liver lobe (2)	N.C.	N.S.
15, M/39	–	Type 5, calcification in liver (0.5)	N.C.	N.S.
16, M/25	–	Right pleural effusion with two lung cyst images (3)	Right pleural effusion, N.C.	N.S.
17,[c] F/43	–	N.C.	Hydatid cyst of right lung (2.5)	N.S.
18,[c] M/9	–	N.C.	Hydatid cyst of left lung (6)	N.S.
19, M/38	+	N.C.	Presumptive hydatid cyst of left lung (1.3)	N.S.
20, F/40	+	N.C.	Presumptive hydatid cyst of right lung (3)	N.S.
21, M/7	–	N.C.	Presumptive hydatid cyst of left lung (3.5)	N.S.
22, M/12	+	N.C.	Presumptive hydatid cyst of right lung (3.5)	N.S.
23, M/60	–	N.C.	Presumptive hydatid cyst of left lung (11)	N.S.

[a] EITB, enzyme-linked immunoelectrotransfer blot assay; positive (+), negative (−). All EITB-positive results were positive to the three diagnostic bands ($M_r = 8 \times 10^3$, 16×10^3, 21×10^3).
[b] Type 1, collection of fluid without daughter cysts (solitary); type 2, collection of fluid with a split wall; type 3, collection of fluid with septa (daughter cysts); type 4, heterogeneous echographic pattern; type 5, reflecting thick wall (calcified cyst).
[c] Surgically confirmed cases.
[d] Figures in parentheses are the sizes of the cysts in cm.

Matched conditional logistic regression analysis was used to assess the independence and strength of variables to identify those individuals at a higher risk of hydatidosis. No statistically significant variables were found. However, those individuals who owned sheepdogs tended to have a higher risk for hyda-

Table 5: **Prevalence of hydatidosis according to infected organs in sheep, cattle and pigs slaughtered at Tupac Amaru, Peru, 1994**

	No. of animals examined	No. of infected livers	No. of infected lungs	No. of infected animals
Sheep	117	75 (64)[a]	101 (86)	102 (87)
Cattle	25	6 (24)	16 (64)	17 (68)
Pigs	8[b]	7[c] (88)	7[c] (88)	7 (88)

[a] Figures in parentheses are percentages.
[b] One animal was infected with cysticerci.
[c] Two animals were heavily infected with cysts in the liver, lung, heart and kidney.

tidosis, and those who did not know how hydatid was transmitted to humans were twice as likely to have hydatidosis.

Discussion

The 9.1% prevalence of human hydatid *infection* (as defined, see above) found in this study is the highest reported in Latin America among studies using similar survey techniques (*13–16*). The 5.7% prevalence of human hydatid *disease* (again, as defined above) in the Tupac Amaru cooperative in the highlands of Peru is similar to that found in north-western Kenyan nomadic populations. The Kenyan group, surveyed only by portable ultrasound, had the highest human prevalence previously known, 5.6% (*17*). Additionally, we found an extremely high prevalence in dogs and livestock which will support the parasite's continued life-cycle and human infection.

The serological prevalence of human hydatid disease has more than tripled in the last 5 years (1.9% to 6.4%), which may partly be explained by a more representative population sample and improvements in the assay. However, it is probable that human prevalence is truly rising. Notably, the prevalence of infected dogs (the source of human infection) has risen 20-fold since 1980 when the control programme ceased (*3*, *5*). The routine inappropriate disposal of infected viscera is the source of the rising dog prevalence. Presumably this increase in infected dogs creates a more heavily infected environment, which leads to a higher human incidence. The 18-fold rise in the prevalence of infected sheep (*3*) during the same period confirms the fact that the environment has become more infectious.

The use of ultrasound and chest X-rays in this study has also augmented hydatidosis detection. The majority of cysts detected by these techniques met criteria for a hydatid cyst (*8*, *9*) or were accompanied by positive serology. Therefore, the false-positive rate is likely to be very low.

Some limitations of hydatid serology have been confirmed in this study. Assuming that all cysts detected by chest X-ray and ultrasound are hydatid, the sensitivity is particularly low in lung cysts (38%) compared to hepatic cysts (57%). This finding is consistent with previous observations (*7*, *16–19*). The 14 seropositive individuals with negative ultrasound and chest X-ray could be explained by aborted infection, undetectably small cysts, or false-positive reactions. Cross-reaction with antibodies to *Taenia solium* was ruled out by testing these 14 sera with *T. solium* EITB, all of which were negative (Moro et al., personal observations). Also, given the extremely high specificity of the assay in prior studies, false positives are unlikely (*7*). Whether these 14 seropositive, yet radiographically and ultrasonically negative subjects will develop clinically evident disease remains to be seen.

Children under 11 years had significantly higher seropositive rates than older subjects, which suggests that transmission is ongoing, frequent, and possibly more intense than occurred previously. This frequent exposure to *E. granulosus* may induce some degree of protection which prevents further development to the metacestode stage. Early acquired immunity may result in aborted infections, and the possibility that this occurs is supported by the finding on ultrasound of atypical images in the liver in three subjects, one of whom was seropositive. In addition, two individuals positive by EITB and double-diffusion assays in the 1989 survey had seroconverted to negative and had no demonstrable disease by chest X-ray (in one) and ultrasound (in both).

An important finding of this study is the high frequency (2%) of lung hydatid cysts in the population, which is consistent with the high incidence of pulmonary hydatidosis seen in nearby hospitals in Huancayo city and in Lima (*20–22*). The ratio of lung to liver cysts was 1:1.75. This contrasts with findings in Argentina, Chile, and Uruguay, where the ratio of lung to liver cysts in autopsy series varied from 1:3 to 1:13 (*23*, *24*). A previous chest radiograph survey close to Tupac Amaru revealed a 3% prevalence of presumptive hydatid lung cysts (*4*). The high frequency of lung cysts seen in Peru may be due to the effect of high altitude, which causes an increased volume of capillary blood in the lungs and increased dilation of capillaries (*25*). The possibility of a local strain of *E. granulosus* with pulmonary trophism should also be explored.

Possible reasons for our inability to demonstrate significant risk factors are that infection may spread beyond a single household and that the study population is relatively homogeneous. Wide geographical dispersal of infection may arise from a single point source of *E. granulosus*-infected dog faeces, as demonstrated in New Zealand (*26*).

The lapse in hydatid control measures since 1980 is responsible for the higher canine, ovine and human disease prevalence. This increase in echinococcosis prevalence was thus the result of premature cessation of the control programme.

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Résumé

Epidémiologie de l'infection à *Echinococcus granulosus* dans la partie centrale des Andes péruviennes

L'hydatidose humaine due à *Echinococcus granulosus* constitue un grave problème de santé publique dans les régions du Pérou où se pratique l'élevage des ovins. Dans les années 70, un programme pilote de lutte contre l'hydatidose comportant une purgation des chiens par le bromhydrate d'arécoline suivie d'un traitement par le praziquantel, a été conduit dans la coopérative agricole Tupac Amaru, dans la partie centrale des Andes péruviennes. Les membres de la coopérative avaient en outre été invités à ne pas nourrir les chiens avec des abats crus. Ces mesures ont toutefois été abandonnées en 1980 et il n'existe pas de données complètes sur l'ampleur de l'infection par le ténia échinocoque chez les hôtes définitifs, intermédiaires et accidentels. La présente étude avait pour but de déterminer la prévalence de l'échinococcose humaine et animale à *E. granulosus* et d'identifier les facteurs environnementaux et culturels jouant un rôle important dans la transmission de l'infection.

La prévalence de l'échinococcose humaine a été déterminée par échographie et radiographie pulmonaire au moyen d'appareils portables, et par sérologie au moyen d'une méthode immunoenzymatique (EITB). La prévalence de l'infection animale a été déterminée chez le chien par examen microscopique des selles pour y rechercher les ténias après purgation par l'arécoline, et chez les ovins par examen des viscères après abattage. Les sujets trouvés positifs à l'un quelconque des examens ci-dessus (cas) et des sujets non infectés provenant de la même communauté (témoins) ont été inclus dans une étude cas-témoins destinée à identifier les facteurs importants dans la transmission de l'infection à *E. granulosus*.

La prévalence de l'infection (sujets positifs pour au moins un des examens mentionnés ci-dessus) parmi les 407 personnes incluses dans l'étude était de 9,1% (37/407). La prévalence de l'hydatidose humaine (résultat positif à l'échographie et/ou la radiographie pulmonaire) était de 5,7% (23/407). La localisation était hépatique dans 3,4% des cas, pulmonaire dans 2,0% des cas et à la fois hépatique et pulmonaire dans 0,2% des cas. Le rapport des localisations pulmonaires/hépatiques était de 1:1,75. Les enfants de moins de 11 ans avaient des taux de séropositivité significativement plus élevés que les adultes, sans signes de maladie à l'examen échographique ou radiographique pratiqué au moyen d'un appareil portable ($p < 0,05$). L'analyse par régression logistique conditionnelle n'a pas fait apparaître de variables statistiquement significatives. Cependant, les personnes qui possédaient des chiens de berger tendaient à avoir un risque plus élevé d'hydatidose, et celles qui ne savaient pas comment la maladie se transmet à l'homme avaient un risque multiplié par deux.

Parmi les 104 chiens examinés après purgation par l'arécoline, 33 (32%) hébergeaient des ténias adultes. Parmi les 117 moutons abattus à l'abattoir local, 102 (87%) étaient porteurs de kystes hydatiques.

La prévalence de l'hydatidose humaine dans cette zone d'endémie est l'une des plus élevées au monde et est cinq fois plus élevée que la valeur rapportée auparavant dans cette même zone. La prévalence de 5,7% de l'hydatidose relevée sur les hauts plateaux du Pérou dans la coopérative agricole Tupac Amaru est similaire à celle que l'on observe chez les populations nomades du nord-ouest du Kenya. Nous avons également observé une forte prévalence de l'infection chez les chiens et les ovins, avec des taux multipliés respectivement par 20 et par 18 depuis l'arrêt des mesures de lutte en 1980. Les enfants de moins de 11 ans ont des taux de séropositivité significativement plus élevés que les autres groupes d'âges, ce qui laisse à penser que la transmission se poursuit actuellement avec une grande fréquence et peut-être une plus forte intensité qu'auparavant.

L'absence de mesures de lutte depuis 1980 est responsable de l'augmentation de la prévalence de l'hydatidose chez le chien, les ovins et l'homme. Cette situation est due à l'arrêt prématuré des programmes de lutte.

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